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State of California
Department of Public Works
Division of Highways
Materials and Research Department

June 12, 1964

II-Sha-3-B
II-Sha-28-C
Lab. Auth. 34175-S

Mr. H. S. Miles
District Engineer
Division of Highways
Redding, California

Dear Sir:

Submitted for your consideration is:

REPORT

of

DEFLECTION STUDY

of

ROADS II-Sha-3-B and

II-Sha-28-C

Study made by ..... Pavement Section
Under general direction of ..... Ernest Zube
Supervision and Report by ..... Raymond Forsyth

Yours very truly,

JOHN L. BEATON
Materials and Research Engineer

Attach.
cc: LRGillis
WLWarren
ELTinney

INTRODUCTION

Deflection measurements have been completed on the two projects listed below in accordance with a teletype request from Mr. J. Hislop on February 4, 1964.

Dist.	Co.	Rte.	Sec.	Project Limits
II	Sha	3	B	Between Sulphur Creek and Project City - Sta. 54+00 to Sta. 600+00
II	Sha	28	C	From Montgomery Creek Sta. 175± to Sta. 619±

Visual observations and deflection measurements over both projects were obtained from April 20 - 23, 1964, with the traveling deflectometer utilizing a 15,000 lb. single axle load.

II-Sha-3-B

The existing structural section consists of 3" AC over 8" Cl. "B" CTB over a variable thickness of ISM. The roadway was built under contracts 53-2TC8-F, 54-2TC13 and 54-2TC14. Construction was completed in August 1955. The alignment traverses rolling hills which required moderate to large cuts and fills. The north and southbound lanes are predominantly fill and cut, respectively. In the spring of 1956, following an unusually wet winter, distress became visible throughout all three projects. Cracking was found to be most frequent in the contract from Project City to Mountain Gate (54-2TC14). Pavement distress was characterized by block, ladder, and "alligator" cracking with some evidence of pumping. At several locations, bleeding of the asphalt surfacing was observed.

As a result of the early distress manifested by this roadway, investigation of causes was carried out by the Materials and Research Department, which included deflection measurements and a sampling and testing program. The results of this investigation were summarized in a memorandum to H. S. Miles from F. N. Hveem, May 6, 1957.

Visual observations made during the April 1964 deflection study indicate that the seal coats and maintenance blankets which have been placed on the project since 1956 have only temporarily alleviated pavement distress.

II-Sha-28-C

The largest portion of the alignment was constructed under three contracts. The first, contract 56-2TC5 (between Mountain Creek and 0.2 mi. E. of Hillcrest (Sta. 11+50 to 205+00)), was completed in December 1956. The structural section consists of 3" of AC surfacing over 6" Cl. "C" CTB over 6 to 12" of imported subbase material. The second, that portion of the roadway between

Sta. 277+00 and 362+50 was constructed under contract 51-2TC9 with 3" of AC surfacing over 6" of crusher run base. The third contract, from Sta. 362+50 to 619+00 (between Debs Place and the summit of Hatchet Mountain), was completed in August of 1956, with a structural section consisting of 3" AC surfacing over 6" Cl. "C" CTB over 6" of imported subbase material. The extremely wet weather which prevailed during the winter of 1955-56 resulted in the loss of surfacing and CTB on a large portion of the latter contract during the winter suspension period. Most of the present visible distress on the roadway is confined to the section built under this contract.

In 1952, under contract 53-2TC3, portions of the roadway from Sta. 13+00 to 178+00 and Sta. 277+00 to 364+50 were subject to repairs in the form of 2-1/2 to 3" AC blankets and a Cl. "B" seal coat.

RECOMMENDATIONS

II-Sha-3-B

Based upon past experience, it is believed that a level of deflection up to 0.024" over an uncracked cement treated base may be reduced to a tolerable limit (0.012") with an increase in gravel equivalence of approximately 5.5". A 3" AC surfacing, therefore, would fulfill this requirement. For levels of deflection in excess of 0.024" a minimum increase of 15" in gravel equivalence is indicated. Because of the uniformly low levels of deflection in the passing lanes and the general confinement of areas of high deflection to travel lane fill sections, a digout is considered to be the most economical approach to the problem. It is therefore recommended that the travel lanes only with evaluated deflection levels of 0.024" or more be scarified to a depth of 8". It is further recommended that cement be added and that the mix be compacted to form a Cl. "D" CTB with a minimum compressive strength of 500 psi in seven days. The entire roadway should then be blanketed with 3" of AC surfacing.

As an alternative to the CTB digout recommended for travel lane fill sections, it is recommended that the top 6" of the existing structural section be scarified, removed, and replaced with a 6" AC base course, bringing the section back to finish grade. Both the travel and the passing lanes should then be blanketed with 3" of AC surfacing.

The following is a summary of recommended corrective treatment for this project:

NBTL	From Sta. 54+00 to 325+00	3" AC blanket
NBTL	From Sta. 325+00 to 514+00	3" AC blanket 8" Cl. "D" CTB
NBTL	From Sta. 514+00 to 600+00	3" AC blanket
SBTL	From Sta. 54+00 to 450+00	3" AC blanket
SBTL	From Sta. 450+00 to 600+00	3" AC blanket 8" Cl. "D" CTB
N&SB passing lanes from Sta. 54+00 to 600+00		3" AC blanket only

II-Sha-28-C

Road curvature and grade precluded deflection measurements with the traveling deflectometer from the beginning of the project to Big Bend Road (Sta. 175±). No recommendation will be made for this section.

Two test sections between Big Bend Road and Sta. 365± resulted in evaluated (80 percentile) levels of deflection of 0.021". These data support the relatively good visual appearance of this section. A 2" overlay will reduce transient deflections to a tolerance level and preclude deflection cracking.

From Sta. 365± to the end of the project (619±) the evaluated deflection level ranges from 0.043" to 0.056". This section is characterized by continuous cracking and rutting. An increase in gravel equivalence of approximately 10" is indicated by past experience to reduce pavement deflection to a tolerable level. This may be accomplished by either of the following corrective treatments:

1. Place a 5" thick Cl. 1 AB over the existing roadway and surface with a 3" AC blanket. Care should be taken to extend the cushion section to the edge of the structural section to insure adequate drainage. Every effort should be made to utilize a relatively free draining AB. If a large proportion of the trucks utilizing the roadway are engaged in log hauling, consideration should be given to a 4" AC surfacing. It is recommended that this alternative be given primary consideration, since it would permit incorporation of the residual strength of the existing section into the new construction.

2. Scarify the existing roadway to a depth of 8" and add sufficient cement for the construction of an 8" thick Cl. "D" CTB with a minimum compressive strength of 500 psi. Upon completion, the entire roadway should be blanketed with a 3" AC surfacing.

ANALYSIS OF DATA

The criteria utilized for evaluation of pavement deflections originated as the result of a comprehensive deflection study which was made throughout the State from 1951-55. The data represents readings from nearly 400 electronic gage units on 43 different projects. The report* on this work presented the limits shown below listing the maximum safe deflection level for several types of structural section, if the pavement is to resist cracking after some millions of repetitions of normal traffic. For purposes of standardization, deflection measurements are obtained using a 15,000 pound axle load.

Thickness	Type of Pavement	Maximum Deflection For Design Purposes (Tentative)
6 in.	Cement Treated Base (Surfaced with Bit. Pavement)	0.012"
4 in.	Asphalt Concrete on Gravel Base	0.017"
3 in.	" " " " "	0.020"
2 in.	" " " " "	0.025"

These values have been applied as guide criteria by the Materials and Research Department since 1955 for planning the reconstruction of existing roadways. To date, no additional evidence has been found which would cast serious doubt on the validity of these criteria insofar as California pavements are concerned.

More recent investigations have produced data as to the deflection damping characteristics of the various structural elements or layers involving gravel base, cement treated base, and asphaltic concrete. Utilizing this information, it is possible to estimate the necessary thickness of surfacing or base required to reduce pavement deflections to tolerable limits. These thickness values may be used in the design of overlays for existing roadways.

The evaluated deflection level (Table I) is the 80 percentile value for all deflection measurements taken in a given section. This value is used as the basis for design since it reflects the deflection characteristics of the roadway as a whole rather than isolating possible causes of distress indicated by averages through cut, fill, cracked, and uncracked sections.

*"Pavement Deflections and Fatigue Failures", F. N. Hveem, 1955.

II-Sha-3-B

For the roadway under consideration, the northbound travel lane from Sta. 54+ to Sta. 325+ resulted in evaluated deflection level of 0.018". Distress in this section was in the form of scattered travel lane block and transverse cracking. From Sta. 325+ to Sta. 514+, the northbound travel lanes are almost entirely over moderate to large fills with an evaluated deflection level of 0.036". Continuous block cracking and pumping was observed in the travel lane OWT. From Sta. 514+ to Sta. 600+ northbound travel lane deflection level was found to decrease to 0.024". This section consists, for the most part, of cut. The southbound travel lane from Sta. 450+ to Sta. 600+ was found to have an 80 percentile deflection level of 0.029" being predominantly fill. From Sta. 54+ to Sta. 450+, the southbound travel lane 80 percentile deflection level was 0.016". This section was almost entirely cut.

The evaluated deflections for both north and southbound passing lanes were well below the 0.012" deflection criteria for a CTB. In keeping with the low level of deflection, cracking was minimal.

The preponderance of visible distress on this project is confined to travel lane fill sections. It is logical, therefore, that the limits of major reconstruction be defined by location of fills on the project.

II-Sha-28-C

As shown by Table II, the summary of deflection test data, the subject roadway divides itself into two sections both with respect to surface distress and magnitude of deflection.

From Sta. 175+ to Sta. 346+ pavement condition is from fair to good with a few localized areas of serious distress. Because of the physical limitations of the traveling deflectometer, it was possible to obtain measurements over only two areas of this section. The 80 percentile level of deflection for these two areas was found to be 0.022" which is in keeping with the generally good visual condition of the roadway.

From Sta. 365+ to Sta. 619+ (end of project) almost continual OWT distress was observed in the form of longitudinal block and "alligator" cracking. In several areas, relatively deep ruts and spalling were evidenced. The 80 percentile level of deflection for this section was found to be 0.048".

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TABLE I
Deflection Test Data
Road II-Sha-3-B

	Station Limits & Lane Designation	IWT Mean	OWT Mean	IWT 80%	OWT 80%	Pavement Condition
1.	Sta. 221± to 232± N.B.T.L.	0.011"	0.014"	0.015"	0.018"	Intermittent patches and cracking.
2.	Sta. 332+15± to 346± N.B.T.L.	0.009"	0.020"	0.015"	0.029"	Continuous large blk. cracks in OWT. Pumping, transverse cracks every 50 to 60' in passing lane.
3.	Sta. 445+50± to 455± N.B.T.L.	0.025"	0.036"	0.033"	0.044"	Large OWT block cracks for the first 150' of run. Remainder continuously alligator cracked in OWT. Pumping.
4.	Sta. 583+09± to 593± N.B.T.L.	0.017"	0.019"	0.022"	0.024"	Large blk. cracks in travel lane.
5.	Sta. 324± to 334± N.B.P.L.	0.004"	0.004"	0.006"	0.006"	Longitudinal cracks in travel lane, transverse cracks in passing lane.
6.	Sta. 455± to 466± N.B.P.L.	0.007"	0.008"	0.012"	0.010"	T.L. still continuously patched with transverse & longitudinal cracks in IWT.
7.	Sta. 587+50± to 577± S.B.T.L.	0.018"	0.027"	0.024"	0.033"	Both lanes appear to have been blanketed recently (1-2 yrs.). Cracking was apparently severe underneath as it is already beginning to reflect.
8.	Sta. 495± to 485± S.B.T.L.	0.010"	0.018"	0.017"	0.024"	Travel lane patched with longitudinal cracks in both wheel tracks. Ladder cracking and rutting in outer wheel track.

TABLE I (Cont'd)

	Station Limits & Lane Designation	IWT Mean	OWT Mean	IWT 80%	OWT 80%	Pavement Condition
9.	Sta. 395+50± to 385± S.B.T.L.	0.009"	0.012"	0.015"	0.018"	Travel lane still newly patched. Condition of pavement generally much better. Some slight longitudinal cracking in OWT. Cracking more severe in IWT. Slight spalling & small patches.
10.	Sta. 307+40± to 297+80± S.B.P.L.	0.004"	0.002"	0.007"	0.004"	Passing lane looks very good complete run. Travel lane begins uncracked, but deteriorates at end of run.
11.	Sta. 286± to 276± S.B.T.L.	0.004"	0.008"	0.008"	0.014"	Travel lane continuously patched. Longitudinal cracks mostly in OWT. Sporadic transverse cracking.

TABLE II
Deflection Test Results
Road II-Sha-28-C

Station Limits & Lane Designation	IWT Mean	OWT Mean	IWT Evaluated	OWT Evaluated	Pavement Condition
EBL ℄ Big Bend Road to Sta. 188+50±	0.014"	0.017"	0.017"	0.022"	Some slight cracking in the IWT. Mix appears to be dry.
EBL Sta. 233+50 to 243±	0.008"	0.014"	0.012"	0.021"	Very sparse longitudinal hairline cracking. Mix appears to be dry.
EBL Sta. 397+87± to Sta. 410+72±	0.021"	0.035"	0.028"	0.043"	Continuous alligator cracking in both wheel tracks with rutting. Distress appears to be more severe in the OWT.
EBL Sta. 507+50± to Sta. 519+55±	0.037"	0.038"	0.053"	0.054"	Alligator cracking throughout.
EBL Sta. 555± to Sta. 565+90±	0.024"	0.024"	0.041"	0.045"	Hairline cracking beginning to reflect through seal coat. Rutting in both wheel tracks.
EBL Sta. 579± to Sta. 590±	0.039"	0.044"	0.044"	0.048"	Block cracking along centerline as well as in wheel tracks. Severe rutting.
WBL Sta. 492+78± to Sta. 480±	0.031"	0.042"	0.041"	0.051"	Longitudinal and block cracking in both wheel tracks. Deep rutting.
WBL Sta. 434+82 to Sta. 424+82	0.047"	0.044"	0.060"	0.055"	Longitudinal alligator cracking in both wheel tracks. Patching and severe rutting.
WBL Sta. 377+05 to Sta. 367±	0.040"	0.046"	0.052"	0.056"	Alligator cracking both wheel tracks with severe rutting.